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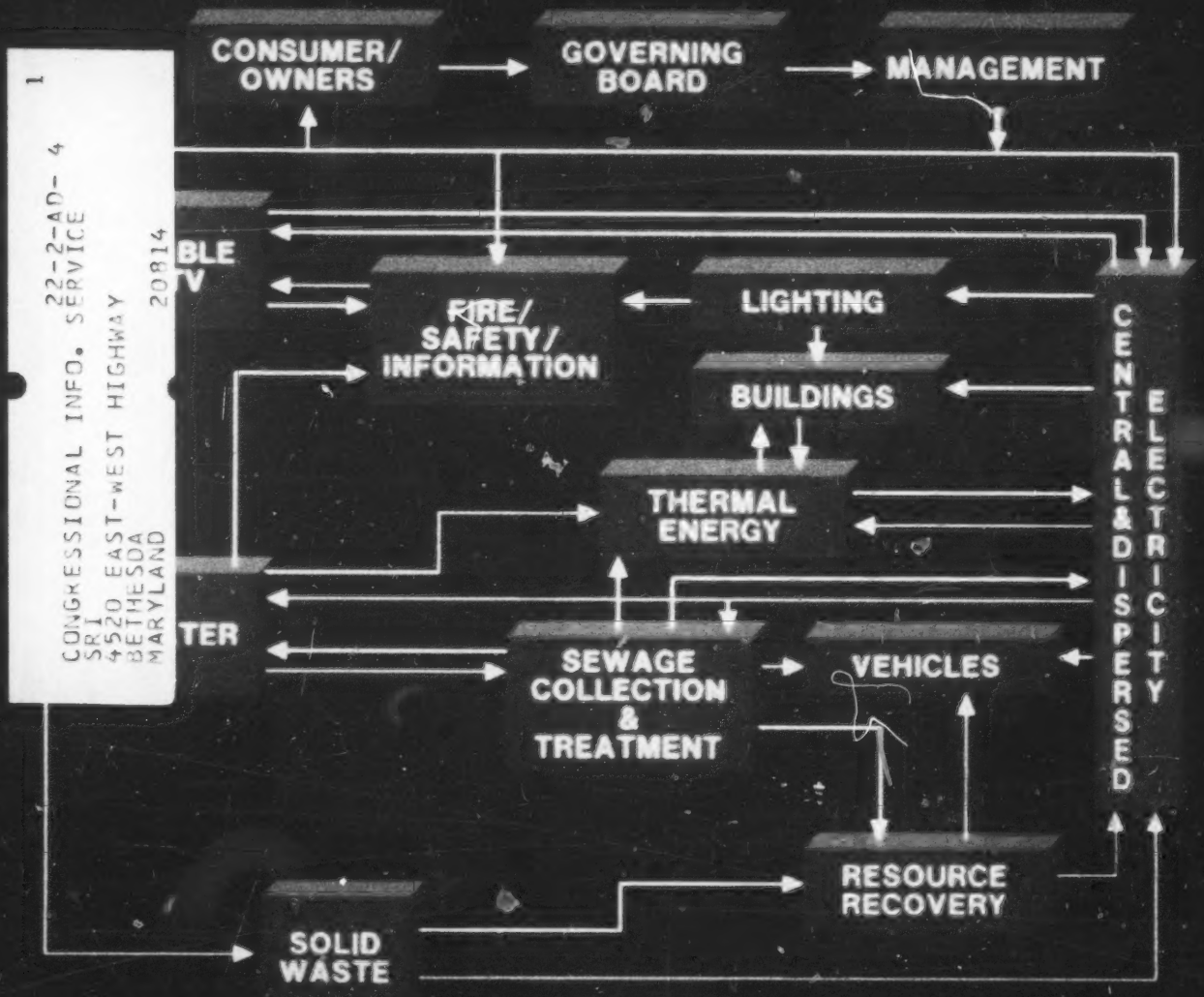

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PUBLIC POWER INNOVATION 1982

public power

NOVEMBER-DECEMBER 1982
VOLUME 40 NUMBER 6

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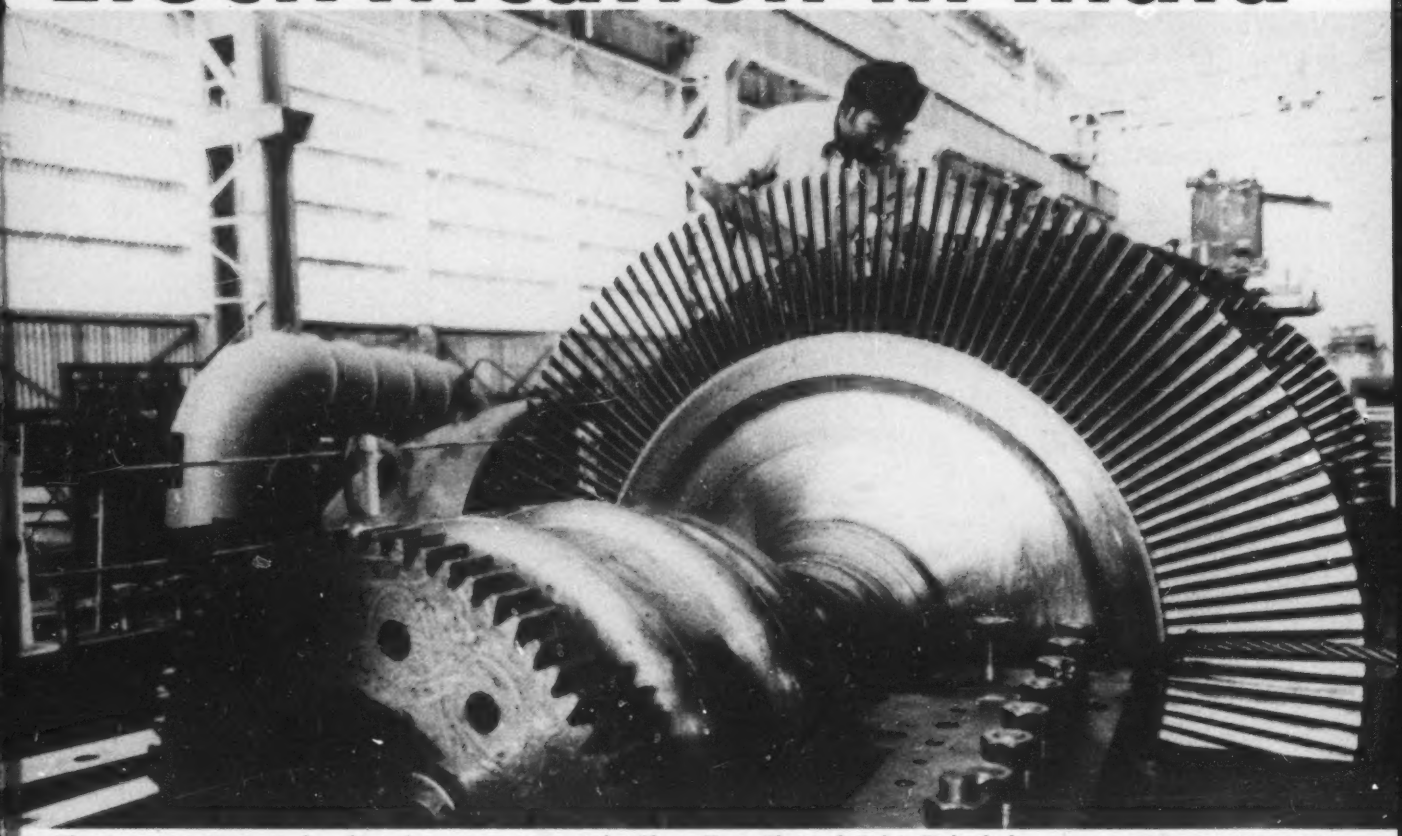
Electrification in India



Electric power equipment such as this turbine rotor is constructed at Bharat Heavy Electricals Ltd. in Hyderabad. PHOTOS COURTESY WORLD BANK

by PETER S. PENNER

INDIA IS 685 MILLION PEOPLE — nearly three times our U.S. population in one-third of our space — packed into cities larger than ours and spread in 570,000 villages of all sizes, shapes and levels of development. Economic development in India ranges from substantially Western standards of living down to a gigantic and growing mass of urban-subsistence poor. Meeting current and future energy needs seems unmanageable. But decentralization at least offers hope.

The Indian people have always exhibited a unique ability to absorb and adopt foreign ideas without sacrificing the strong fabric of their culture. One of the best examples of this is the Indian state itself, which attempts to guide and control the Indian economy from a central government derived from rough-and-tumble democracy. Unpopular policies are frequently greeted by massive strikes, walkouts, speeches, rallies, newspaper editorials and riots. But somehow the nation holds together and develops more or less — usually less — according to the official government five year plan.

In India the twin issues of resource base and population overshadow all political, economic, energy and environmental policy. The government projects that population growth will slow to 1.1 percent by the year 2000, leaving about 800 million Indians in its care. The recent decennial census has shown no slowdown in birth rates indicates this assertion is questionable.

Penner is an electrical engineer who recently traveled in India under the sponsorship of the National Science Foundation and Indian Institute of Management. He is now chief engineer in the governor's office of consumer services in Chicago, Ill.

Editor's Note: This is the seventh in a series of articles PUBLIC POWER has asked various authors to prepare regarding electrification in foreign countries.

Local Sources Supplied Energy

For centuries, India met its minimal energy needs with nothing more than wood, animal dung and sunlight. No one knows how much of these sources are still used in the villages. Government officials estimate that this "non-commercial" energy use dropped from 68 percent of all energy consumed in 1954 to 44 percent in 1976.

Coal is needed in reliable supply for railroads and power plants; the railroads sometimes have problems delivering sufficient stock to both industries. Coal mining in India is so devoid of mechanization that it is considered a labor-intensive industry.

Ambitious plans are under way to expand offshore petroleum drilling and thereby bolster the country's negative balance of payments. All petroleum-related activities are handled by the state-owned Indianoil company, which has the unique mission of reducing the size of its business rather than expanding it. The company maintains a conservation consulting service authorized to

order any conservation found cost-effective, under threat of cutting off oil supply to uncooperative customers. Motor gasoline is a luxury in India, while kerosene is a necessity for many, so the company strongly depresses gasoline sales to insure adequate supplies of cooking fuel.

Little Interest in Solar

There is an enormous reliance on natural, renewable energy forms in India, but most of this is simply the continuation of age-old patterns of supply and demand. The major renewable energy forms in use are hydroelectricity, draft animal power, animal waste and firewood. There is no substantial interest in "biogas" plants, small digesters which convert animal wastes into high-quality methane usable for cooking or conversion to electricity in a small, portable generator.

About 85,000 of these plants are in place. However, they are not technically advanced devices and are built by contractors who offer little or no marketing and service backup, so no one knows how many are still working. There appears to be little interest in solar and wind power other than small demonstration programs and perfunctory references in government reports.

As part of the nation's highly centralized planning effort, the government planning commission in 1979 issued a "Reference Level Forecast" (RLF). It represents the likely level of demand for energy if no deliberate measures are undertaken to manage energy supply and demand over the next 20 years.

Electricity demand is strong in India, even though installed capacity has increased nearly 20-fold since 1950, from about 1,700 MW to about 30,000 MW. Demand has consistently outpaced supply by about 15 percent, according to government estimates.

Maintenance, Transmission Poor

There are a variety of reasons why the supply side continues to fall short. The main ones are:

1. Average capacity factor at power plants is an abysmal 45 percent system-wide, because of maintenance problems;
2. An inadequate and unreliable transmission system consumes 20 percent of generation, more than double U.S. losses;
3. New projects take much longer to complete than official plans call for and are much more costly than anticipated. (Does that sound familiar?)

Chronic electricity shortages have interesting ramifications. First, the country has extensively studied and implemented methods of allocating power cuts to industrial areas. Secondly, India has become one of the world leaders in demand management, using its central powers to schedule electric use by large customers, notably irrigation systems. As a result, India's load factor is one of the world's highest — 63 percent — and its annual peaking demands are almost entirely due to increased irrigation pumping during the summer and winter dry seasons. Still, many cost-effective conservation measures are not implemented because electric rates for industry are well-subsidized.

Cow dung, urine, night soil and finely chopped fodder remnants are mixed in a tank in Ugala, India, left, to obtain biogas, which is used for household cooking, right. Size of the popular biogas generators ranges from 60 to 5,000 cubic feet capacity.

Figure 1 shows the current fuel configuration of the Indian electric utility industry and capacity additions projected by the year 2000. Supporting data are imprecise, but estimates put fossil generation at about 75 percent coal and 25 percent oil. The power system is so undersized that all capacity added is designed for base load. Total peak demand is about 27,000 MW. The RLF shows peak demand growing to 95,800 MW by the year 2000, with total capacity tripling to 129,700 MW — an ambitious and probably unreachable goal. The central government's less ambitious "Optimal Level Forecast" projects 101,020 installed MW by the beginning of the next century.

'The power system is so undersized that all capacity added is designed for base load.'

At present, there are 640 MW of nuclear capacity on-line, but nuclear provides only 3 percent of total electrical energy. The Ministry of Energy Power Committee has recommended that 5,000 MW of nuclear power be installed by 2000 and hopes that thorium reactors can be a major fuel source thereafter. India has one of the world's largest thorium deposits but little uranium.

Although two minor nuclear incidents have been reported, nuclear power is not yet an environmental issue. However, last year a new era in Indian energy policy began with a letter to the editor of a local newspaper by a group of environmental professors criticizing in detail a proposed government hydroelectric project. Environmental objections to a new power project are unusual and the government has constituted an ad hoc committee to review the complaints of affected landowners.

Utility Organization Vexing

The organization of the Indian electric sector is both elaborate and confusing, and is generally acknowledged to be the source of many of the industry's problems. In 1956, the Industrial Policy Act halted private power companies' growth and reserved further expansion for the State Electricity Boards (SEBs). These boards exist for all but two Indian states and consist of seven members appointed by state governments.

Board members need no special qualifications, nor must they work full-time, but most boards have at least three full-time officials — the chairman, technical member and accounts (finance) member. The SEBs are free to assign members to head activities such as generation, distribution, or administration — although they often do not — and are free to structure their rather large organizations. The SEBs have gradually taken over all but three private utilities and now own more than 70 percent of installed capacity.

Due to increasing interstate disputes over water rights and transmission lines, the central government created five regional electricity boards to coordinate power planning and development. The national government also created the National Thermal Power Corp., the Atomic Power Authority, the National HydroElectric Power Corp. and one centrally owned regional generation company much like our Tennessee Valley Authority. These four systems have about 7.5 percent of installed capacity. Private companies still own about 5 percent, a handful of municipals own 1 percent and the remaining 14 percent is owned by an array of multistate public ventures. The entire sector is coordinated by the Central Electric Authority, a division of the Energy Ministry, which provides most of the national expansion planning, coordinating, performance monitoring and technical consulting services.

'In India the electric power sectors rate and financial structure is a political matter often unrelated to the dictates of rational finance.'

The poor performance of the electric sector's generating plants is generally blamed on the number of organization levels and on the SEBs. A 1980 report of the Ministry of Energy's Committee on Power summarized the problems as follows:

> "The major problem areas are inordinate delay in the commissioning of the power projects, the poor utilization of power plant capacity and heavy financial losses. Although these are partly the result of factors outside the control of the boards, they cannot but reflect on the quality of their management. During the last few years, their performance has on the whole deteriorated.
>
> "In personnel terms, the reason is not far to seek. The boards have not been exposed to modern management systems and an achievement oriented and commercial culture. Apart from salary consideration, they do not provide the kind of environment required to attract and retain young and enterprising engineers and experts in other disciplines.
>
> "The industry has been and is even today slow and insensitive in responding to the general public's expectations of a power supply of reasonable quality and reliability and also to consumer complaints. There is a general tendency among the staff to exploit conditions created by their position to a monopoly in power supply in a period of power shortages."

In addition, there is a feeling that the SEBs have grown too large, do not use sufficiently sophisticated planning techniques and are patronage outlets for state governments.

Rate-Setting Highly Political

Obviously, such inefficiency could not survive in a tight fiscal environment. But in India the power sector's rate and financial structure is a political matter often unrelated to the dictates of rational finance.

For political reasons, some industrial, agricultural, and rural electrifications tariffs are set far below actual cost of service. Only two of the 18 SEBs actually received average revenues per kWh greater than their average cost in 1977-78, while all others posted losses of up to 50 percent.

Furthermore, the changeover to unmetered flat-rate tariffs — because many meters are stolen — inevitably encourages overconsumption. SEBs have often been unable to pay their operating expenses plus interest on indebtedness plus depreciation, meaning that one or more went into partial default during a given year.

Power production financing has generally come from three sources: loans from state government (57 percent), private "market borrowings" (25 percent) and internal resources (17 percent). Heavy reliance on state loans makes the SEBs highly vulnerable to state political pressures, usually concerning favored ratemaking and patronage employment. Although a recent law allows states to convert their debt holdings to SEB equity, no state has yet done so.

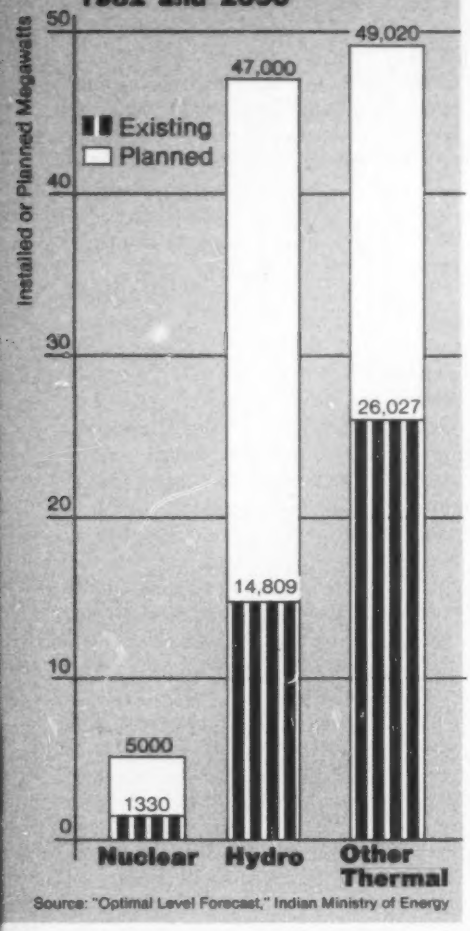
Until 1978, SEBs were required to pay expenses, including depreciation and financing new plants, prior to repaying loans to the state and other investors. With rates heavily subsidized most loans not surprisingly remained partially or completely unpaid. In 1978 interest repayments were given a higher priority than depreciation, so the latter is now suffering the effects of insufficient cash. Also in 1978, the first legal precedent was established requiring electric revenues to at least recover all costs including debt cost.

Although the World Bank and other outside lenders require new Indian projects to attempt to earn an 11 percent return, the sector as a whole now reportedly earns an average return of 7.5 percent against an average 6 percent cost of money. These returns, however, vary widely among states and are often understated due to general disagreement on accounting principles and treatment of state loans. There are no universal accounting procedures and such matters as enforced loans from ratepayers, depreciation rates and the like are all up to the whim of the SEBs involved.

Microcosm of World's Ills

In many respects, India represents a scaled-down version of our world and its dramatic discrepancies in income, resource allocation and economic structure. India is playing out on a national scale the conflicts of resource distribution that must be faced on the international level: population control, income distribution, petroleum dependence, and capital-constrictions on an increased energy supply.

Figure 1 **Republic of India Existing and Planned Generating Capacity, 1982 and 2000**



Source: "Optimal Level Forecast," Indian Ministry of Energy

Two major courses of events are distinguishable more clearly in India than in a world too large to permit one a vantage point.

In the first, population comes under control and the country makes a concerted effort to reduce the imbalances in income distribution. This may mean forsaking the growing investments in defense systems, atomic energy, possibly even electrification, and all areas which primarily benefit the upper classes, in favor of investments in railroads, renewable energy and improved rural technologies.

The second path is characterized by a failure to check population and redress the balance, a tendency that is difficult to reverse when a sizable and powerful upper-middle class is adamant in its belief that further development means advancing its authority and urban lifestyle.

An excellent case in point is the Indian rural electrification program. Running electric lines to remote villages is seldom cost-effective in the short run. However, based on the expectation of important benefits such as irrigation, increased agricultural productivity and an improved rural light-industry base, the government has invested heavily and expects to reach every village by the year 2000.

Meanwhile, there is growing evidence that rural electrification benefits are questionable, particularly in light of the grossly inadequate generation and transmission system. Because irrigation loads are by far the largest peak load, their use is tightly scheduled. Combined with the unscheduled but frequent down-times, many farmers have decided electrification is not worth the trouble and have switched over to diesel pumpsets even though the cost is much higher.

The government calls a village electrified when the first hookup is made. Even though agricultural rates are heavily subsidized, straining the finances of the entire system, only about one customer in 10 can afford to pay hookup costs and install wiring — namely the relatively rich landowners. The municipalities are too poor to afford street lighting.

Yet a growing wealth of information and pilot projects attest to the existence of a number of decentralized, cost-effective, and environmentally sound alternative means of electrifying villages.

A good example of such a project is the "Rural Energy Center" being developed in the Central Indian village of Puna by the well-known Indian scientist A. K. N. Reddy and his colleagues. The center revolves around a village-size biogas generator supplied by the local farmers. Over the course of the day, the gas produced is shuttled to needed areas of the village. In the morning it fires several community cooking rings so hot water and hot breakfasts can be made without long hunts for firewood. The gas is then shuttled to a small converted electrical generator which is first used for pumping up a day's supply of water and then devoted to work-day industrial uses. By night, the remaining gas can be shifted back to the cooking rings (for dinner) and the generator (for electric lights).

Energy is rightly characterized as one of the prime tools of economic development. There is little doubt that an increased energy supply is vital to both economic advancement and the furtherance of education, health and population control efforts. However, the technologies that supply the energy do much to influence the structure of industrial development, employment patterns and lifestyle change. For India and for much of the developing world, the question is really how much of this supply should come in the form of electricity and how much of this electricity should come from large, distant power plants.

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The unusual spray pattern of water at the spillway of the new La Grande power house in Quebec results from a design that slows and broadens the stream of water to minimize bank erosion downstream. PHOTO BY WALTER D. HARRIS

by WALTER D. HARRIS

WITH A FLICK OF A SWITCH Quebec's newest powerhouse roared to life last June, sending another burst of electricity from the burgeoning La Grand hydro complex. Like the power station already operating downstream, the new facility is part of Hydro-Quebec's mammoth effort at harnessing the hydroelectric potential of the Canadian province's vast James Bay territory.

But unlike the first station commissioned in 1979, much of the electricity from the new units will be exported south to the Northeastern United States. Although La Grande complex originally was designed to meet only Quebec's needs, the sudden slowdown in energy demand growth now means Hydro-Quebec must promote electricity exports. Fulfillment of its ambitions for hydro power now hinges on the energy appetite of New York and New England.

The prospect of a greatly expanded energy trade concerns not only Quebec. From the Great Plains to the Atlantic Ocean, Canadian provinces find themselves awash in energy. They look to U.S. needs to justify popular job-creating construction projects.

For Americans, Canadian energy such as Quebec's hydroelectricity is a relatively cheap and abundant alternative to foreign oil. By the end of this year Manitoba is expected to reach a major energy swap agreement with Nebraska and the Dakotas. This year, for the first time, Canadian nuclear power is being imported from a recently commissioned plant in New Brunswick.

In addition, large-scale development of tidal power on the Bay of Fundy is the objective of a pilot project starting up next summer in Nova Scotia. All this new trade in Canadian energy has major U.S. and Canadian electric utilities rewriting their long-range plans.

Geography Transformed

It is hardly exaggeration when Hydro-Quebec, a provincial government-owned firm, boasts of the epic proportions of La Grande complex. Already an underground powerhouse has been carved out of the Canadian Shield's primordial rock. Several rivers have been rerouted. And reservoirs have engulfed the region's terrain — a landscape of bogs, unnamed lakes and scrubby pine barrens known as the tiaga. Six hundred miles north of Montreal, frontier towns sheltered a peak work force of 16,000. When construction ends, the towns will be dismantled and their traces covered by replanted forests.

When Hydro-Quebec first planned the La Grande project it ran into a storm of controversy from Indian tribes and environmentalists. But with the provisional government committed to its favorite project the opposition was quashed by substantial payments to Indians and promises of strict environmental management.

After a decade of work, Hydro-Quebec's subsidiary, Société d'énergie de la Baie James (SEBJ), has completed three quarters of La Grande's first phase. Since the glacier-sheared topography is marked by little relief, dams and reservoirs provide the height needed to exploit La Grande River. Three other rivers — the Eastmain, Opinaca and the Caniapiscau — are being

continued on page 80

Harris is a free-lance writer whose articles on energy have appeared in the CHRISTIAN SCIENCE MONITOR, ECONOMIST *and* ENERGY DAILY.

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channelled into La Grande for added thrust.

Phase 1 generated its first electricity ahead of schedule and its $14.6 billion (Canadian)* price tag is below original cost estimates. The first power station is the biggest hydroelectric plant in North America, with a 5,328-MW capacity. By February 1984 the third station should start up, to complete La Grande phase 1. In all, this phase of construction will add 10,282 MW to Hydro-Quebec's generation.

The system has even bigger plans. La Grande phase 2 calls for construction of four reservoirs to feed five powerhouses with an installed capacity of 3,263 MW coming into service from 1989 to 1993. The French Canadians also want to exploit the Baleine watersheds. In this subarctic region north of the La Grande complex where the tiaga gives way to tundra, Hydro-Quebec plans to build three reservoirs by 1991 and three underground 2,895-MW powerhouses.

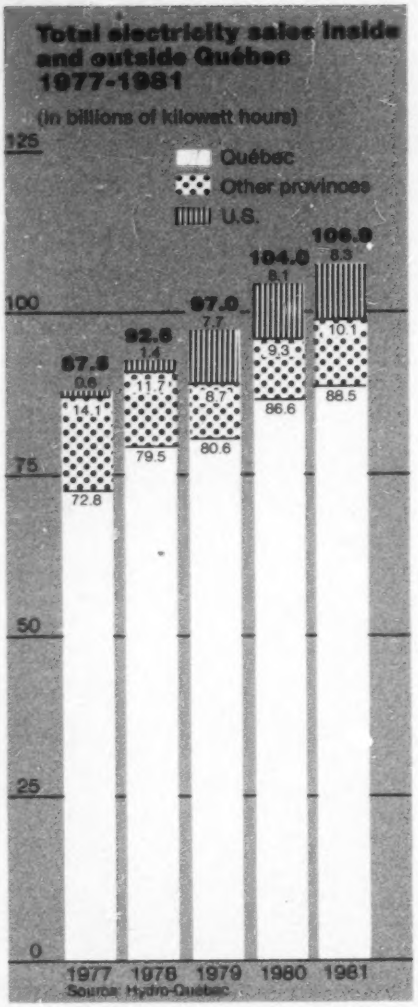
The firm is eyeing yet another area south of La Grande. The Nottaway-Broadbeck-Rupert complex would provide a hefty 7,435 MW from 11 generating stations on the lower reaches of the Broadbeck River. The original timetable had the complex would begin operating between 1992 and 1995. If development at this and other sites in northern Quebec proceeds on schedule, Hydro-Quebec will fully tap the province's hydro potential by the end of the century.

Forecasts Too High

These plans stem from official projections of Quebec's energy demand. In November 1981 the company forecast a 6.1 percent average annual growth in the province's energy consumption through 1998. But sharp jumps in energy prices are holding down demand; the official projections announced in October place annual growth at 3.7 percent, and few observers believed the figure had bottomed out.

Hydro-Quebec officials have been revising the demand forecast and preparing a public announcement on a new long-range plan, including a rate hike request and delay of new construction until 1988. And the system's top-heavy management has been shaken up.

These and other signs suggest that Hydro-Quebec's heyday is over. In 1981, after almost a decade of uninterrupted income growth, its net income decreased more than



25 percent to $558.8 million from $746.2 million the year before. Interest expenses and depreciation on new hydro facilities coincided with depressed electricity demand. In October 1981 the province embarked on an eight-year energy conservation drive to improve home energy efficiency and reduce consumption by 32 percent. Accordingly, the hydro system — Quebec's largest industrial enterprise in terms of assets — cut back 1982 capital expenditures by some $440 million.

PASNY Big Purchaser

Into this scenario stepped New York and New England utilities interested in buying Quebec's surplus power. The news this year was a contract signed in March for Hydro-Quebec to sell the Power Authority of the State of New York (PASNY) up to 111 billion kWh between 1984 and 1997.

PASNY has been importing Quebec hydro since 1978. At present it buys about 8 billion kWh per year, accounting for 20 percent of PASNY sales and 7 percent of New York state's electricity needs. The new contract is significant, though, because it points to a policy shift in Quebec, away from exporting temporary surpluses and toward major long-term foreign sales.

Quebec and New York already benefit from a "diversity power" arrangement complementing each others' needs. During peak demand periods from April to October PASNY has been buying firm power from Quebec, where lowest energy demand comes during the warm months. Under the deal, PASNY paid for hydro power at a rate about 80 percent the cost of oil-fired generation. More recently prices fell, reflecting shared savings of both New York's oil replacement and Quebec's hydro costs. This promise of still cheaper hydro spurred PASNY to sign the long-term power contract.

New York state enjoys a sizeable electricity surplus, but 60 percent of its capacity is oil-fired. Through conservation, coal conversion, and imports from Quebec, the state has trimmed oil-fired generation from 45 percent five years ago to 31 percent last year. The latest contract with Quebec means New York utilities can lessen their oil dependence even faster, and save their customers about $100 million per year.

While New York expands its transmission hookup with Canada, Hydro-Quebec is planning a new link with another previously undeveloped market. During the early 1970s, New England utilities approached Hydro-Quebec about purchasing James Bay hydro. The French Canadians, however, expressed little interest. At the time, the province was bullish on its economic outlook. Hydro-Quebec expected rapid energy growth and insisted on developing hydroelectric power only to meet its own needs. The James Bay project symbolized Quebecois pride.

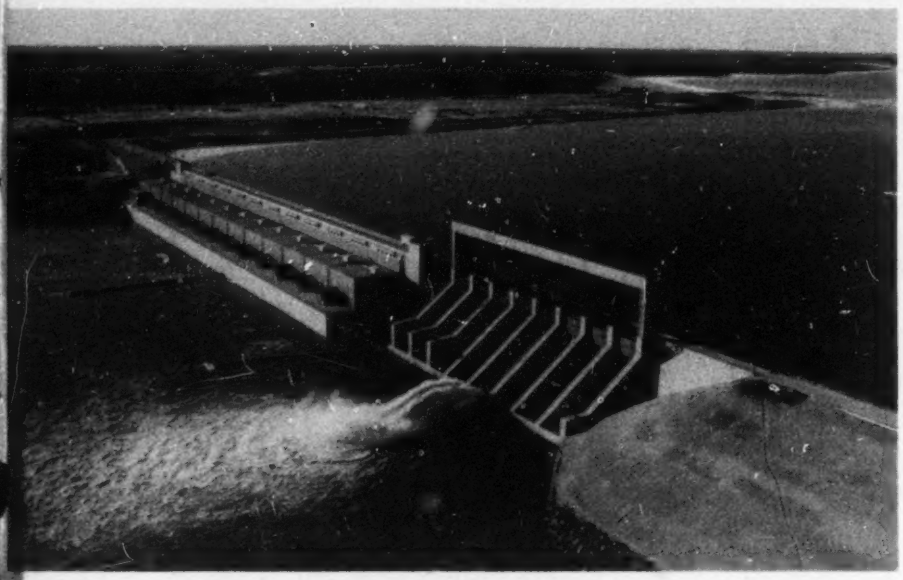
New England Tying In

In the gloomy 1980s, though, with a slumped economy pointing to energy surpluses for years to come, an interconnection to New England becomes a major concern. This June, Hydro-Quebec and the New England Power Pool (NEPOOL) — consisting primarily of investor-owned utilities but including some municipals — signed a letter of intent to build the tie between their two systems and embark on extensive energy trade.

NEPOOL has applied to New Hampshire and Vermont regulatory agencies for permits to construct a transmission tie to Sherbrooke, Quebec, near the Vermont border. Plans call for 690-MW capacity hookup eventually expanded to 2,000 MW.

The proposed tie is opposed by Yankee landowners unhappy over the prospect of a

**References to Canadian expenditures throughout this article are in Canadian dollars, each worth about 80 cents in the United States.*



Electricity from Manitoba's largest power plant, the Kettle Generating Station on the Nelson River (top), now flows south to Winnipeg then to Minneapolis, Minn., via a 500-kV transmission line (right). The MANDAN *project would include a similar line from Winnipeg through the Dakotas to Nebraska.* PHOTOS COURTESY MANITOBA HYDRO

transmission line cutting through their woods. To complicate matters, NEPOOL has found the regulatory process in New Hampshire more cumbersome than expected. But NEPOOL expects to have by this winter the permits needed to build the interconnection. Canadian hydro would begin flowing into New England by the mid-1980s.

Construction of the transmission line would easily pay for itself by enabling Quebec and New England to set up an "energy banking" procedure. NEPOOL would, in a sense, deposit its energy in Quebec reservoirs and call up this reserve during peak demand hours. In doing so, NEPOOL could avoid much of the oil-fired generation now used during peak hours.

Besides the energy swap, the interconnection will, of course, provide a major hydroelectricity export route to New England — the agreement sets a target of 33 billion kWh between 1986 and 1997.

Like PASNY, NEPOOL stresses that Quebec's hydro will be used only to reduce oil imports while coal conversion and conservation efforts proceed. The hydro will not replace new American electricity capacity, such as the planned Staten Island coal- and refuse-burning plant or the nuclear units under construction at Seabrook, N.H., and at Millstone in Waterford, Conn. New England now has about a 40 percent capacity surplus, so, with the nuclear power coming on line during the 1980s, the region should be supplied for years to come.

For Quebec, the chief question is whether New England and New York will purchase enough Canadian energy to justify continued hydro-power construction. The American market, once viewed as an outlet for sporadic surpluses, now is recognized as a key factor in Quebec's future.

The increasing importance of hydro exports is already apparent, as the accompanying graph shows. This year, U.S. sales will reach 8.3 billion kWh. By 1984, New York imports will reach 12 billion kWh. And by 1986, New England will begin importing an average of 3 billion kWh annually. Last year alone, Hydro-Quebec's sales to the U.S. and other provinces brought in $375 million — a 25 percent increase over the year before. The new contract with PASNY will bring in about $400 million per year.

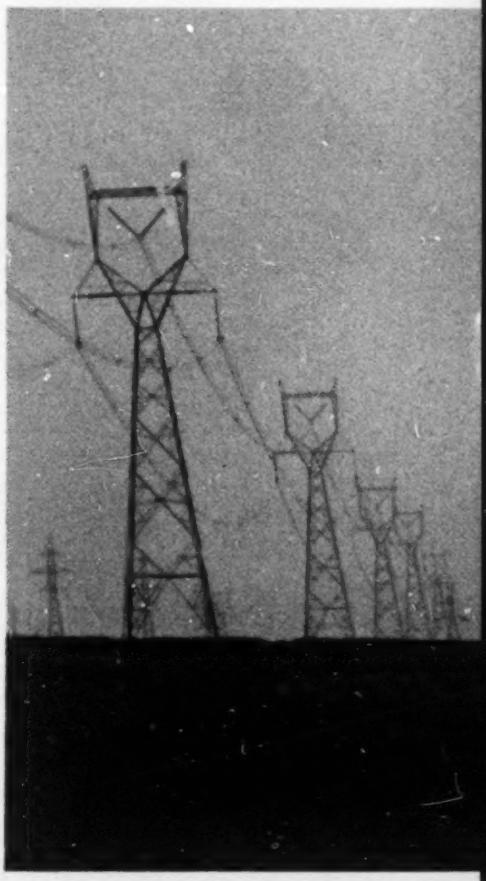
MANDAN Project Beneficial

Midwestern public power systems also seek major imports of Canadian hydroelectricity. Wayne Jacobsen, a spokesman for the Nebraska Public Power District, points to the mutual benefits the MANDAN project will provide the one province and three states which gave the project its acronym, Manitoba, the Dakotas and Nebraska.

Construction of a 500-kV AC line from Winnipeg, Manitoba, to Nebraska, with substations in North Dakota and South Dakota, will permit seasonal energy swaps between the regions. Utilities south of northern South Dakota with summer peak load requirements want to draw on the excess summer capacity of their northern neighbors. Dams on Manitoba's Nelson River, whose watershed encompasses much of the area between the Rockies and Hudson Bay, could begin sending their power south by 1988. Construction costs on the American side of the border are expected to reach $686 million, Jacobsen says, but Nebraska's share would still be half the cost of building a new coal-fired plant to meet summer peak loads. Utilities in other Midwestern states besides Nebraska and the Dakotas may join the MANDAN project.

Other Canadian provinces are closely watching this expanding energy trade with the United States. They are pushing their own energy development plans and, like Quebec, their pet projects are in jeopardy as the American market reaches its saturation point.

U.S. imports from the New Brunswick Electric Power Commission are nothing new. What is new this year is the first import of Canadian nuclear power, from the Pointe Lepreau station now coming on stream in New Brunswick. This CANDU (Canadian Deuterium Uranium) facility, on the shores



of the Bay of Fundy between Saint John, New Brunswick, and the Maine border, is the first nuclear power station in the Atlantic provinces.

During the 1970s, New Brunswick failed to convince Nova Scotia and Prince Edward Island to share either the power or the financial risk of Lepreau. So NB Power responded to overtures from New England

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The Annapolis Royal tidal power project in Nova Scotia is to be completed next summer.

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utilities. Boston Edison — which last year cancelled its own nuclear power project — has signed up for a block of Lepreau's capacity, as have Massachusetts Municipal Wholesale Electric Co. (MMWEC), Commonwealth Electric Co., a Massachusetts investor-owned firm, and utilities in Maine. The New Englanders have already committed themselves to 335 MW over a six- to nine-year period — more than half of Lepreau's 630-MW capacity. In buying into Lepreau, New England relieved New Brunswick — a small and poor province — of a heavy financial burden.

Now that Lepreau is built, however, construction workers in the area wonder where to find new jobs. NB Power and trade unions are pushing for another unit adjacent to Lepreau 1. This summer, NB Power asked New England utilities about their interest in buying into a second nuclear power plant.

New Brunswickers concede that the second unit will be a lot harder to sell than Lepreau 1. The first station could compete easily with oil-fired generation. But by the time Lepreau 2 would go into operation, much of New England's oil-fired generation will be replaced with coal — a far more formidable competitor.

Transmission Inadequate

Another hitch in expanded energy trade is inadequate transmission capacity, says MMWEC Chairman James E. Baker, president of the American Public Power Association. Massachusetts municipal utilities, such as the one Baker manages in Shrewsbury, would like to buy more Lepreau power. As yet though, Maine utilities have not promised to provide additional transmission capacity needed to move more Canadian power to the Bay State. Despite the hangup, Baker is optimistic about benefits of replacing imported oil with New Brunswick nuclear.

When Canada's National Energy Board approved New Brunswick's nuclear power exports, the decision stirred interest in Ontario. Until construction of Lepreau, all of Canada's nuclear power was in Ontario. Last year that province relied on nuclear for more than one-third of its electricity and by 1990 more than half the demand might be met with nuclear. Ontario Hydro considers its nuclear power the energy resource with the greatest export potential. As utilities in the Northeast convert from oil- to coal-fired generation, Ontario's surplus coal-generated electricity loses its competitive edge.

Since the 1950s Ontario has had major interconnections with New York and Michigan, on which the systems were to rely during emergencies. Over the past decade, though, Ontario expanded the trade with major exports of surplus coal power, from five billion kWh in 1973 to 11 billion kWh last year. Ontario Hydro was negotiating sale of 1,200 MW, via a hookup under Lake Erie, with General Public Utilities, which has paid dearly to replace capacity lost through the Three Mile Island nuclear accident. The deal fell through, which suggests the market may be reaching its saturation point.

Despite the potential, Ontario is cautious in its hopes for more exports. It must now compete with Hydro-Quebec for the New York market. And the escalating cost of nuclear power suggests Ontario may have a hard time finding a U.S. buyer for firm power from nuclear plans yet to be built.

Tidal Power Tested

A similar problem plagues Nova Scotia's drive for large-scale tidal power. Schemes to harness the Bay of Fundy tides have been bandied about since the early 1900s, but none of the ideas has proven economically viable.

A $46 million test of a new tidal power design is under way at Annapolis Royal, Nova Scotia. The Tidal Power Corp. — a provincial government-run firm — hopes completion of the pilot project next summer will boost a proposed $6 billion tidal power dam and station. The plant would be built at the eastern end of the Bay of Fundy where the Minas Basin meets Cobequid Bay. But advocates of tidal power must address the environmental issues raised by their proposals. One problem is the buildup of silt. Another is the effect of water displaced by a huge dam on the tides of the Maine coast.

Experience so far at Annapolis Royal seems to have sparked more interest in applying its cost-saving turbine to low-head river hydro than to large-scale tidal power. In its search for financing Tidal Power Corp. expects no help from Ottawa. Nova Scotian officials expect to have financing proposals ready by the end of the year. But the idea has yet to capture the imagination of possible New England purchasers. A large tidal power station taking 10 years to construct could be ready in the late 1990s. Given the changes in electricity cost, demand and generation in the past decade, power planners on both sides of the border have a difficult task projecting their customers' needs and the best ways to meet them 15 years from now.